at Stockholm, from 9.7° to 3.0°. Therefore, to account for temperature amplitudes of 20° or more, which are common in continental climates in temperate zones, there must be increased amplitude in *temperature effective energy*. Table 1 indicates that this may be brought about through a decrease in cloudiness and in surface evaporation, both of which conditions commonly are characteristic of continental climates.

Under "Applications" the effects of variations in the average amount and the annual distribution of cloudiness are discussed. Since such variation would affect the evaporation and also the reflection from snow surfaces, the equation for $Q_m - R_m$, the *heat* effective net radiation is considered in connection with the equation for θ. In this case $d\theta/dt = c(T_w - \theta)$ as before; but $T_w = T_o + kQ$.

From the values of θ and Q at times of maximum and minimum values of θ the values of k and γ are found to be 0.0022 and 555, respectively.

The annual average percentage of possible sunshine for Stockholm is 39. Assuming this to be uniform throughout the year we obtain a Fourier series for θ_c which gives an annual temperature 1.2° lower and an amplitude 1.1° less than the series for θ. Assuming the skies to be cloudless throughout the year the series for θ_o is obtained, which gives an annual temperature 1.8° higher and an amplitude 6.3° greater than the observed.

The influence of variations in the value of the solar constant with the 11-year sunspot period is also considered, and it is shown that a solar-constant variation of 3.0 per cent over this period would cause the temperature to be 0.4° higher at sunspot maximum than at sunspot minimum, provided the variations in solar intensity did not cause variations in atmospheric transmissibility. As a matter of fact there are indications of increased cloudiness at sunspot maximum, especially at the cirrus level, so that actually the mean temperatures are a little lower at maximum than at minimum of solar spottedness. For this and other reasons the effect of solar variability upon earth temperatures is not clearly apparent.

It is pointed out that considerations quite similar to those here applied to annual variations of radiation and temperature, are applicable to semiannual and daily variations, with, however, a probable change in the value of the constants.

The results obtained seem to the reviewer to indicate that changes taking place within the atmosphere are capable of producing greater temperature variations, and therefore greater weather changes, than can be brought about by solar constant variations of the order of magnitude that are indicated by researches that have been published up to this time.

BROADCASTING WEATHER MAPS BY RADIO

551.509

By B. FRANCIS DASHIELL

[Forecast Division, Weather Bureau, Washington, D. C.]

It is a long step from the first broadcasting of a brief coded weather bulletin issued by the United States Weather Bureau from the Naval radio station NAA, at Arlington, Va., on July 13, 1913, to the transmission, through the same station, of the first complete radio weather-map picture on August 18, 1926.

Arlington's weather bulletins are familiar to nearly all radio operators and navigators. It was most fitting, therefore, that the opening of this new era in the dissemination of weather information should be done through the same station that made the original weather broadcasts in 1913.

The possibility of using radio for transmitting weather maps by the system to be described in this note is based on the fact that C. Francis Jenkins, its inventor, had already transmitted pictures, writing, etc., by his "Television" method. This method appeared to hold great possibilities for the Weather Bureau. If pictures could be sent, why not weather maps? Acting on this idea, E. B. Calvert, chief of the Forecast Division of the Bureau, suggested a conference, at which Mr. Jenkins's invention was inspected and its possibilities as a transmitter of weather maps discussed. The ultimate result of this conference was that, on August 18, 1926, the Navy Department cooperating, a special weather map was taken to the Arlington Radio Station, whence it was radioed to the Weather Bureau with remarkably good reproduction. (See Figure 1.)

In order that extensive tests might be conducted, the Navy Department not only generously loaned the services of its most powerful transmitter at Arlington, operating on 8,300 meters and using from 20 to 40 kilowatts, but it also conducted reception tests aboard U. S. S. *Kittery* and U. S. S. *Trenton* at sea.

The first transmission, on August 18th, was so satisfactory that on August 23d the Chief of Bureau invited members of the press and interested Government officials to a demonstration. Naval officials commented on the value that such a device would be to navigation, and the press of the country carried descriptions of the apparatus.

The tests of radio vision apparatus for broadcasting daily weather maps to ships at sea, as well as to others interested, though still in the experimental stage, show that such broadcasting is sound in theory and has considerable promise of being entirely practicable. But little is known as to the effectiveness of operation over considerable distances and during unfavorable conditions, such as static, wave-length interference, fading, the rolling of vessels, etc. These potential sources of trouble are being gradually investigated. Reception by the *Trenton* and *Kittery* was not entirely satisfactory, due to static and the rolling of the vessels, but maps were received by the *Kittery* as far south as Guantanamo Bay, Cuba. It is hoped that more tests can be conducted under seagoing conditions as improvements in radio and in the mechanical part of the transmission are made from time to time.

The Weather Bureau's experience, as well as that of the observers aboard the naval vessels, is that a map can be received through much static without destroying its value. All static impulses passing through the radio set are recorded as marks of various lengths on the map. This static would seriously interfere with ear reception of coded bulletins and, in many cases, may prevent the obtaining of sufficient data to prepare a map at sea. One map was received at the Weather Bureau during a heavy thunderstorm but the isobars and other data were quite legible. Incidentally, the recording of static impulses by this machine show some interesting actions of the electric waves that are propagated by lightning discharges.

In order to conduct still further tests under other conditions a 45-meter short-wave transmitter of the Jenkins Laboratories at Washington is also used. A short-wave receiver has been built at the Weather Bureau and will soon be in use. The use of the short-wave sets will enable such tests to be carried on whenever desired and without restriction. Experiments are being carried on between Washington and Chicago using both short and long-wave transmissions. Further experiments will be conducted at the central office to determine the ability to register isobars and weather data on printed base maps instead of transmitting an entire map for reception upon plain paper. It is also hoped to speed up the time of reception from 50 minutes to approximately 15 minutes.

Since the first weather map was transmitted in August, several changes have been made in the machine design, to better adapt it to weather-map transmission. Daily tests of reception have shown marked improvement and maps of good quality are now being received. However, as reception conditions are well above the average in this case—the distance between Arlington and the Weather Bureau Office being but a few miles—we must await the results of the not yet thoroughly tested distant transmission, Arlington to Chicago, before we can know the performance of the machines under long-distance conditions.

A description of the operation of the Jenkins system in transmitting the weather map will be of interest. A map is drawn in black ink on a special base. (See Figure 2.) A photographic negative is then made of it, by direct contact printing. This is taken at once to the broadcasting station and placed in the transmitting machine.

The transmitter consists, in brief, of a glass cylinder, about which is wrapped the photographic negative. The cylinder is revolved at a constant speed by an electric motor. Within the cylinder is a small but powerful electric light. Outside of the cylinder is a light-sensitive photo-electric cell which is arranged so as to move along in front of the length of the cylinder at the rate of one-fiftieth of an inch for one complete revolution of the cylinder. This cell has a very small aperture and the light from within the glass cylinder passes through and affects the sensitivity and electrical conductivity of the cell. The electric light within the cylinder advances with the cell so as to be always opposite the aperture.

As the black and white portions of the film (the whites being transparent and the darks opaque) rotate before the aperture of the cell, the light passing through from within is intermittently cut on and off and the conductivity of the cell is varied accordingly. But as the cell is advancing along the cylinder from one end to the other at the rate of one-fiftieth of an inch to each revolution and the diameter of the aperture is the same, it will be seen that the same transparent place on the film never passes before the cell opening more than once. As the light is broken up into impulses of various durations by the white lines of the film, it causes corresponding variations in the electrical resistance of the cell. These resistance changes cause sharp fluctuations in the flow of current through the cell.

In order that this very weak current may be strengthened so that it will operate the relays of the powerful radio set, it must be passed through a number of alternating current transformers and amplifying electron tubes. A pulsating direct current through the cell is obtained by breaking up the light waves by means of a chopper wheel rotating in front of the electric light within the cylinder. This pulsating current can be transformed into alternating current so as to pass through any number of amplifying units necessary. The signals sent out by the radio station are similar to code signals except that they are a meaningless jumble of dots and dashes which are confusing to the uninitiated radio operator.

These may be received by any type of radio set capable of tuning to the wave lengths used and, after being suitably amplified, are passed to the map reproducer. A sheet of white paper is wrapped about a rotating cylinder of the same size as the one on the transmitter. Both cylinders operate as nearly as possible at the same speed and, as the radio impulses come in, a magnetic pen traces lines on the rotating paper to correspond with the transparent whites of the negative. The pen advances at the same rate as the electric cell before the rotating cylinder and the map picture is reproduced by a large number of fine lines marked in their proper positions and drawn in a very flat spiral around the paper on the cylinder. (See Figure 3.)

If the speeds of the two machines differ, the picture will be more or less distorted. Constant and equal speed of both machines is mechanically impracticable; hence it has been found necessary to synchronize the cylinders at each revolution. A special synchronizing master signal is transmitted at the end of each revolution of the sending machine, to hold the receiving cylinder from revolving until the end of this signal comes. In this way each new revolution begins in synchronism with that of the transmitter. The hesitation at the end of each revolution is very slight, but it is sufficient to keep any number of receiving machines in perfect step with the transmitting machine.

A photographic recorder is not used as such a machine is complicated and requires the use of dark rooms, careful handling of sensitive films, and the development and printing of the completed picture, all of which consume valuable time. The receiver now used instantly reproduces with ink and, when the last signal impulse is recorded, the map is complete.

HORIZONTAL GROUND DAY VISIBILITY AT ELLENDALE, N. DAK.

551.591 (784)

By LESLIE A. WARREN

[Weather Bureau Office, Ellendale, N. Dak.]

This paper is based on one year's observations at Ellendale, July 1, 1925, to June 30, 1926. Observations were made five and six times daily, at sunrise, 7 a. m., 10 a. m., 12:30 p. m., 3 p. m., 5:30 p. m., 8 p. m., and sunset. The sunrise, 7 a. m., 5:30 p. m., 8 p. m., and sunset observations were taken during part of the year only and not during the remainder, depending upon the time of sunrise and sunset. In addition to the record of visibility, certain other meteorological elements seeming to have more or less direct influence or effect on visibility were observed and recorded.

This paper confines itself principally to tabulating visibility frequencies and percentages of occurrence as they relate to the several other meteorological elements.

Unfortunately the topography about Ellendale is such that from our observation field east of town the only direction in which objects at greater distances than 9,000 meters can be seen is toward the southeast. The view